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Wood challenge to Steel and Concrete Forest Research
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FOREWORD

This little booklet is one of a series of publications which are being issued from time to time by the Timber Development Section of the Forest Research Institute at Dehra Dun. A list of other booklets issued or to be issued is given at the end of this publication.

In the past, steel and concrete have been looked upon as the chief structural materials of the engineer. This has been due to the fact that these two materials have been widely advertised and strongly assisted by powerful organisations, whereas wood being nobody's child has gone by default.

Recently in some advanced countries there has been a distinct change in favour of wood, and engineers are discovering that far from being only an unimportant auxiliary, wood is the most economical and practical material for many modern structural purposes.

There are two reasons for this change. The first is that wood can now be made durable for a very long period, and the second is that new ideas in timber joints and wood structures have been evolved which place wood on a very different footing to that of twenty years ago. If the question of primary and recurring costs are considered, increased use of wood as a structural material is also justified.

In conclusion, it is a well known axiom that there is a right place and a wrong place for everything, and it is not the intention that wood should be looked upon as the favoured and pampered child of wealthy parents. All we ask is that it should be given a fair hearing and that engineers "honestly and without prejudice" should consider the ideas presented in these booklets, use their own special qualifications to check them up and give treated timber the same consideration as they give to other structural materials. The Forest Research Institute will welcome their help and co-operation for it holds that timber can stand on its own merits and in not a few cases will be found still standing when other materials have fallen.

H. TROTTER,
Forest Economist,
Forest Research Institute.

DEHRA DUN;
June, 1936.

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CHEAPER AND BETTER GABLE ROOFING WITH WOOD SHINGLES

BY

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For a building to act as " a shelter " for its inmates and contents, it is necessary for it to be weatherproof and water-tight at all times. Rain, wind, cold and heat should all be prevented from penetrating, and the comfort and usefulness of a building must depend therefore to a considerable extent on the soundness of its roofing. On the score of economy and also of safety in earthquake areas, the question of roofing is one of considerable importance. The object of this pamphlet is to examine in outline the present day types of roofing found in India, and to suggest a cheaper and better type. A brief description of the manufacture, and the methods of preserving and laying this improved type of roofing, and also a critical survey of its initial and ultimate cost as compared to other roof coverings, are also included.

1. **Types of roofing now in use.**—Generally speaking, there are flat roofs and gable roofs. For flat roofs, either the well-known steel I girders-and-jack-brick-arches type, or mud or lime plaster laid over either clay tiles, bamboo matting, reinforced concrete or brick slabs, or over wood planks supported on wood or steel joists, appear to be popular.

As far as gable roofs are concerned, corrugated galvanised iron sheets (either 22 or 24 S. W. G.) are increasingly employed. Pan and Mangalore tiles are rapidly disappearing. They are heavy, and have been proved unsafe in earthquake areas. Galvanised iron sheets are usually fixed over wood purlins which are nailed or bolted to wood or steel rafters usually at 3 ft. intervals. Naturally, the cost per 100 square feet of this roofing varies widely in different parts of the country, as corrugated iron sheeting is either imported or obtained from one locality only in this country.

Considering, firstly, the flat type of roof, the steel I girder and Jack-arch (4½" brick) type costs, per unit, between Rs. 35 and Rs. 40 if lime mortar is used, and about Rs. 45 to Rs. 50 if cement morta

is employed. This type of roofing is not quite safe in earthquake areas, *i.e.*, practically all over northern India. First class mud roofing, 6″ in thickness, and laid over two layers of 12″×6″×1¼″ tile costs about Rs. 20 per 100 sq. ft. This is used only in poor houses. The more expensive and reliable types cost between Rs. 35 and Rs. 45 employing either wooden planks or reinforced concrete or reinforced brick slabs for supporting brick in mortar. The latter types of supports are three to four times as heavy as wood planking supports. Galvanized sheet roofing costs between Rs. 35 and Rs. 45 per 100 sq. ft. depending on the type of construction adopted. Such a roof is fire-resistant, and lasts for 20 to 30 years in dry localities. In wet localities and near the sea coast, the life of this type is often only 8 or 10 years, unless it is frequently painted and has received in the first place a heavy and efficient galvanizing treatment. Its chief advantage is that it is light and costs little to put up. Metal roofs should be earthed with a wire, otherwise they tend to increase the risk of damage from lightning. It is notorious, however, that they give practically no protection against either heat or cold, unless they are laid over wood planking or, better still, for maximum comfort, covered with wooden shingles. In either case, the cost goes up, but such roofs do give a very desirable type of construction besides prolonging the life of the metal roof. Covering galvanised sheets with wood shingles reduces the noise of rain on the metal sheets and prolongs the life of the sheets. This type of construction deserves the serious consideration of engineers in India. Very satisfactory and economical results can be obtained with galvanised iron sheets and wooden shingles if the galvanising is well done (zinc not peeling off) and the sheets are not too light. If possible, sheets with a minimum of 2½ ounces of zinc per square foot on either side should be purchased. 22 S. W. G. thickness should be used.

2. **Considerations in selecting roofing.**—On account of the generally more expensive nature of really efficient flat roofs (in initial as well as in maintenance costs) for the present, only the different types of coverings of gable roofs will be considered. The construction and relative economy of flat roofs employing wood planks or plywood supports will be considered in a subsequent publication. The slope of the roof and the strength of the roof frame-work are the first factors that determine the choice of a suitable covering. There is a minimum slope which is necessary for different types of roofing. With corrugated metal sheet, a minimum slope of 3″ per foot is necessary. With wood shingles

a minimum of 6″ per foot is desirable to prevent leaks. Attic accommodation will be easily available if a wood shingle roof is selected, whereas with the smaller slope employed with galvanised iron and because of the great heat immediately below such sheeting, it is almost impossible to provide any comfortable living accommodation under such roofs.

It should be borne in mind that the cost of roofing varies with the type of roof to be covered. A plain surface costs naturally the least, while one with many ridges, valleys, chimneys or dormers will cost considerably more. Very steep roofs obviously cost more than flatter roofs on account of the larger area of surface to be covered. The proximity to centres of supply of the different types of roofing is another determining factor.

Before choosing a roofing material, maintenance and repair costs, and the approximate length of service expected of the building, should receive consideration. Facility to repair the roofing when, after some years of service, it needs attention is another important consideration. In this respect and also as regards the anticipated scrap value of the roofing, wood shingles have a clear advantage over galvanised iron sheeting which can with difficulty be repaired when parts of it are corroded. A permanent house or structure warrants a more expensive roof than a semi-permanent one. Pressure preserved wood shingles can be considered to be practically permanent.

There is also the question of fire resistance which is sometimes wrongly overstressed as an argument against wood, and which in some cases is not considered at all. It is obviously necessary to have a covering that will not readily burn when sparks from chimneys fall on it. There are over a million square feet of oil-treated wood shingles in the grounds of the Forest Research Institute at Dehra Dun. Those shingles are about 13 years old and there have been no rejections. In congested areas in towns and cities, however, it is preferable to have wood shingles fireproofed. There will then be no risk whatsoever in employing them, but in country areas the fire-proofing of wood shingles is not considered necessary. In the United States of America, there are several million wood houses with wood shingles, and according to the underwriters the fire risk of such houses is no more than that of brick and stone houses, as in 99 per cent. of the fires recorded, it has been the contents of the houses that caused the fire. In England, insurance rates on wood houses and brick masonry houses are identical and low, amounting to only 1*s*. 6*d*. per £100 of the initial cost.

The general appearance of a building is another consideration in the choice of roofing materials. In this connection wood shingles have an inherent beauty that permits the attainment of very good architectural effects with practically any type of building.

The action of the elements where the air is laden with acid fumes as in industrial districts or with particles of salt as in places near the sea, shortens considerably the life of galvanised iron sheets. Rapid corrosion follows, especially as an electric couple is set up as soon as the zinc disappears from the surface of the sheets. Treated wood shingles and solid sheathing are ideal for such conditions, and are unaffected by acid fumes, salt or corrosion.

Asphalt and tar roofs, especially in the hot plains of India, have to be covered with sand or slag because, when fully exposed to the sun, these materials deteriorate rapidly. Because of their dark colour, they absorb considerable heat, and they tend to make a building very hot inside.

In the choice of a roofing material, consideration should also be given to the question of insulation against heat and cold. Insulation against heat becomes an absolute necessity in India when galvanised iron is used, even if the building covers only animals or birds.

Finally, where the inside of a building is kept warm and the outside is very cold, as in the cities of Northern India like Quetta, Peshawar and Lahore, the question of "condensation" on the inside of galvanised sheeting is important. Treated wood planking below the iron sheet acts as an insulator and reduces condensation to a minimum.

3. **Wood shingles and substitutes**—Over twenty billion wood shingles are sold annually in the United States of America and Canada alone. They are usually of cedar, redwood, or cypress and they are sold in bundles of 250 standard size pieces. The most common sizes in vogue are 4″ × 12″ or 5″ × 15″. They have a tapering cross-section along the length, the thin end being 1/16″ thick and the butt end being 5/16″ to 3/8″ thick. Only about a third of their (butt-end) surface is actually exposed to the elements.

To cover 100 sq. ft. of roof surface, if the shingles are 4″ wide, 900 shingles are required. If they are 5″ wide, 720 shingles are necessary. If a width of 6″ (practically the maximum width in use) is employed, 600 shingles are sufficient.

In India, the actual cost of treated wood shingles to cover 100 sq. ft. works out at about Rs. 10 to Rs. 15 as against an average cost of about Rs. 25 for some other types of composition shingles

Wood shingles can be made practically anywhere in India while asbestos or composition shingles are practically all imported from abroad. Freight charges have to be added for transporting them to places in the interior.

According to the Guide of American Society of Heating and Ventilating Engineers (1928), the heat loss or gain per sq. ft. per hour in the case of wood shingles is about 80 per cent. of that with composition or asbestos shingles, assuming that *all the three types are laid over building paper fixed to a wood planking deck.* If a wood planking deck is not used, composition and asbestos shingles make the building so hot that it is no use considering seriously such a type of construction. While the wood and composition shingle roofing costs about the same, the asbestos shingle roofing costs, with the above life of construction, about 25 per cent. more.

Properly treated wooden shingles are durable, comparatively cheap, and light. They require, therefore, only light supports. They neither rust nor corrode. Their colour is also attractive. After one dipping treatment, no further treatment or painting is required for shingles used either for the roof or for the sides of a house. If however, once every five or six years, a shingled roof receives a light brushing coat of the preservative (an inexpensive proceeding) the appearance and the life of the roof are improved. Wood is also an excellent insulator against heat, cold and sound, and wooden shingles are easily laid. If relaying of a roof is required, new shingles can be nailed over the old ones so that the building need not be uncovered. It thereby obtains added insulation and protection. There is also no rubbish to clear away after re-shingling is done.

4. **Indian woods suitable for shingles.**—Durability, light weight, nail-holding capacity, and comparative freedom from checking, warping, and twisting when exposed to the elements are the important qualifications of shingle woods.

Practically all the principal Indian conifers (deodar, pine, spruce and fir) are ideal for shingles and can be used not only for roofs, but also for covering the sides of houses. They are light, and, therefore, shrink and swell less than most hardwoods. Among the hardwoods, the lighter and more generally common woods like semul (*Bombax malabaricum* and *Bombax insigne*), haldu (*Adina cordifolia*), mango (*Mangifera indica*), salai (*Boswellia serrata*), papita (*Sterculia campanulata*), gamari (*Gmelina arborea*), gutel (*Trewia nudiflora*), black and white siris (*Albizzia* spp.), toon (*Cedrela toona*), white cedar (*Dysoxylum malabaricum* and

Dysoxylum binecteriferum), and kuthan (*Hymenodictyon excelsum*) deserve attention.

5. **Method of making wood shingles.**—Although shingles are made in Western countries with special shingle-making machines, an ordinary 24″ circular saw bench and a suitable template (as shown in the sketch opposite) can produce 5,000 shingles (sufficient to cover about 700 sq. ft. of roof) in a working day, by employing one sawyer and two unskilled labourers, so that the cost of labour for preparing shingles per 100 sq. ft. comes to only 4 or 5 annas.

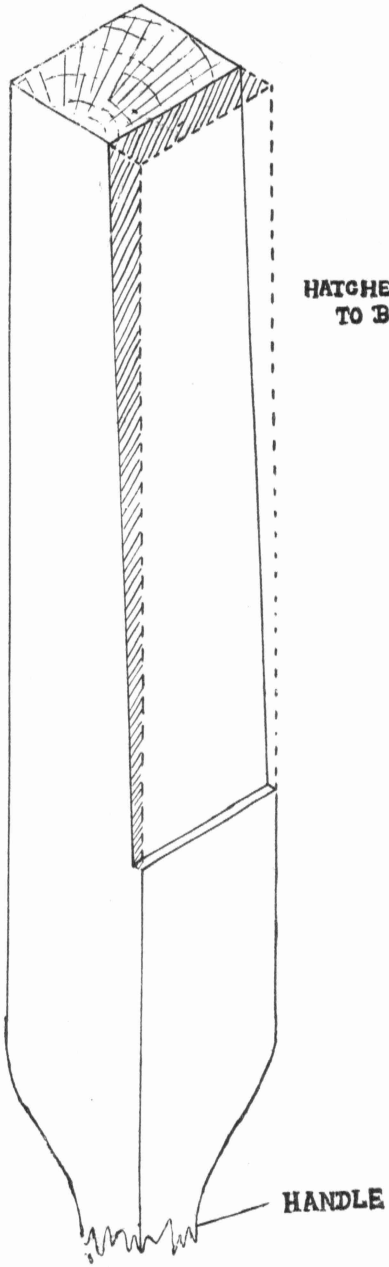
The method of sawing shingles on an ordinary saw bench has been described by W. Nagle, Officer in Charge of the Wood Workshop Section, Forest Research Institute, Dehra Dun, as follows :—

" Where an automatic shingle cutting machine is not available, the method best employed is to first cross-cut the timber, which should be air-dried as far as possible to prevent cracking, into blocks 15″ long by 5″ square, or to the maximum thickness of the wood at hand, not under 4″ or over 6″ thick. This done, a wooden tapered fence is made for use as a template-guide against the permanent fence of the saw bench.

To do this, a piece of timber, preferably hard wood, 2′-6″ long by 4″×2″, is taken. A hand grip is shaped at one end, and from the other end a distance of 15″ is measured down. A line 3/8″ from edge is struck at end of template to the 15″ mark, allowing it to run in taper to 1/16″ from the edge. The piece so marked is cut away from the stick, giving a tapered recess on one side. The next step is to set the saw bench fence 3″ from saw. The straight edge of the template is placed against this with the recess nearest the saw. Into the recess the 5″×5″ block of wood is placed, and shingles are cut turning the block, end for end, after each cut, to keep it parallel."

The best results are obtained with radial or edge-grain shingles—which shrink or warp, in general, only half as much as flat-sawn shingles with tangential grain on the flat surface. For ensuring a light durable roof and for rapid laying, shingles should be preferably 18 in. or 24 in. long and 4½″ to 5″ wide.

6. **Durability of Indian wood shingles.**—Most of the soft woods and the lighter hardwoods of India suitable for shingles are not durable. Except for the heart-wood of durable woods like deodar, teak and cypress, shingles of practically all woods


HATCHED PORTION
TO BE CUT OFF
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require to be preserved against white ants and fungi. The preservative used should be of the "fixation" type so that it is not washed out by rain. The shingles may be stained to any desired colour. The preservative should preferably not contain oil as oil treated shingles burn very fiercely once they catch fire, and the fire becomes worse if attempts are made to put it out by using an ordinary water hose, and it is not always possible to have pressure chemical extinguishers at hand. The Forest Research Institute, Dehra Dun, should be consulted as regards the use of the best wood preservative for the purpose. *Properly pressure preserved shingles should last almost indefinitely.* The average cost of such a treatment is estimated to be about Rs. 2 per 100 sq. ft. of roofing surface.

7. **Fireproofing wood shingles.**—Wood shingles can also be made highly fire resistant by pressure impregnation with a solution of 12 per cent. ammonium borate after they have been first preserved with an efficient "fixation" wood preservative like Ascu. The average cost of a pressure fireproofing treatment amounts to about Rs. 2 per 100 sq. ft. of roofing. For improving the fire resistance of untreated wood shingles, they may be painted (instead of being pressure treated with a chemical solution) with a suitable fireproofing paint.

8. **Methods of laying wood shingles.**—Wood shingles are either laid over a solid wood sheathing consisting of wood planking nailed to the rafters, or over an open deck of roof laths fixed to the rafters. In regions with a heavy rainfall it is desirable to interpose a sheet of building (tarred) paper between the shingles and the wood planking or the laths. When a solid sheathing is employed for roof spans of about 30 ft., a section of 2 inches × 6 inches for rafters of any softwood, or 2″ × 4″ of hardwoods like sal may be employed. If, however, wood laths are employed, the cross-section of the rafters can be reduced by a third, the spacing between rafters in each case being the same, namely 18 inches. The laths may be of 1″ thick and 2 to 3 inches wide, laid with an intervening space of about 2 to 3 inches which will not only give the required base for nailing the shingles, but also permit circulation of air for ventilating purposes. After a shower of rain, if such ventilation is provided, the upper ends of the shingles dry rapidly. This type has some merit in warm and rainy regions although not for the really better class of buildings. The two sketches on the next page indicate the two types of base on

which wood shingles may be laid. At least two-inch long nails should be used to securely fasten the board or lath to the rafters.

It may be pointed out that, on the whole, the solid wood sheathing, although slightly more expensive, is desirable, as it makes the construction more fire-resistant and definitely improves the insulation of the building. Its fire resistance is estimated to be about 15 minutes in an ordinary building fire. Also, it has the advantage of giving a smooth base for fastening the shingles. The roof boards should preferably be planed over the broad surface to which shingles are fixed.

Shingling should be commenced from the wall plate and proceed upwards towards the ridge. Wood shingles should be soaked thoroughly in water before being laid. The nails should be 1½ inches long, and copper or zinc-coated, hot-dipped cut iron nails should be used.

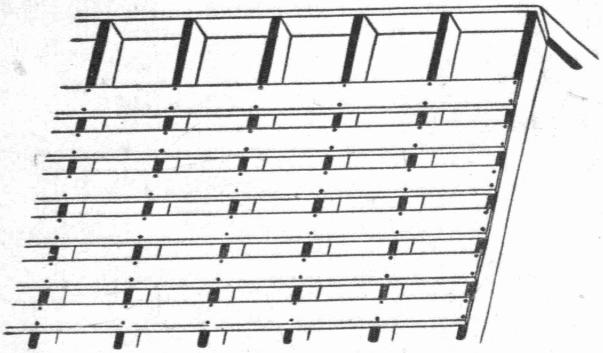
The first course of shingles should be laid double, allowing a projection of 1½ to 2 inches over the crown mould, and an inch projection at gables. If shingles are not thoroughly wet, a space of 1/8″ between 5″ wide shingles should be left. Those timbers that swell greatly when damp may require a 3/16 inch spacing. The heads of the nails should not be driven into the shingles. The joints should not be broken closer than 1¼″ side lap. It is also better for the breaks not to come directly over each other on any three consecutive courses.

Shingles under 5″ in width require 2 nails for each board or lath whereas with wider shingles 3 nails are necessary. Wherever there is an opening in the roof, zinc or copper flashings should be placed around it. The same provision should be made for taking care of valleys where gables join. As it has been already stated previously, the pitch of the roof for a shingle roof should not be less than 6 inches per foot of rise, or 1 in 4 for a gabled roof.

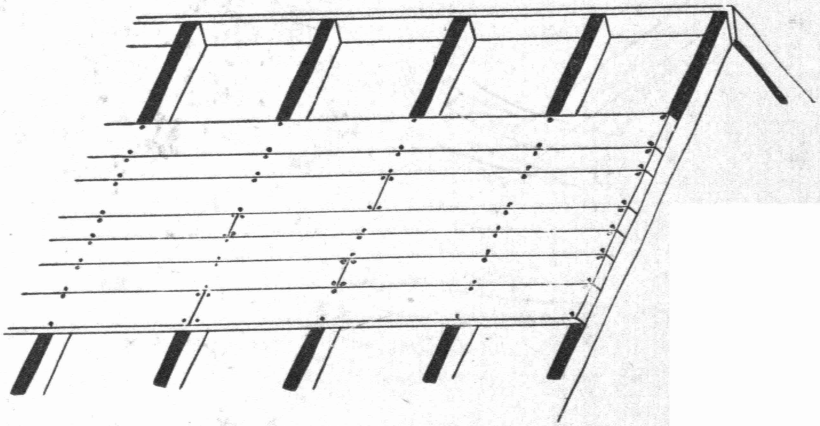
9. **Cost of wood shingles.**—If a solid wood sheathing (1″ planking) is employed as the base, the average cost per 100 sq. ft. of shingling is as follows :—

1. Cost of making and preserving shingles.

(a) Cost of wood for yielding 700 shingles 15″ × 5″ × 3/8″ thick at butt end and 1/16″ thick at thin end .	Rs. 12-8 to Rs. 15-8.
Average .	Rs. 14.
(b) Cost of copper or zinc-coated nails .	Rs. 3.
(c) Conversion labour, power and depreciation	Rs. 3.
(d) Preservative treatment . . .	Rs. 2.
Total .	Rs. 22.



OPEN SHEATHING.



SOLID SHEATHING.

N.B. THERE IS A THIRD TYPE OF CONSTRUCTION WHICH IS A CHEAPER AND MORE OPEN TYPE OF "OPEN SHEATHING". WOOD NAILING STRIPS $1\frac{1}{2}$" THICK AND 2" WIDE ARE NAILED TO RAFTERS AT CENTRES CORRESPONDING TO A THIRD OF THE LENGTH OF THE SHINGLES USED.

2. Cost of sheathing (1″ thick) and nails—
if solid sheathing is used Rs. 12-8.
3. Cost of sheathing and nails if $1\frac{1}{2}'' \times 2\frac{1}{2}''$ nailing strips are employed . Rs. 2-8.
4. Labour . . . . . Rs. 2-8.

Therefore, the total average cost of wood shingling over a solid wood sheathing would work out at about Rs. 40 per 100 sq. ft. It will be about Rs. 33 if nailing strips are employed instead of a solid sheathing. Considering the wide variation of conditions in India, the above figure should be taken as varying between Rs. 35 and Rs. 45 per 100 sq. ft., so that it does not work out initially more expensive than ordinary galvanised sheeting while offering one of the finest looking roofings known and a maximum of insulation comfort. If properly treated timber gives a life of at least 25 years when laid in the ground, a life of at least 40 or 50 years can be confidently expected of treated wood shingles or of shingles laid over galvanised iron sheets. For earthquake areas in northern India, treated wood shingles laid over treated wood sheathing affords the most comfortable, artistic, economical, and safe roof known to architects and engineers to-day.

LIST OF PAMPHLETS TO BE ISSUED BY THE TIMBER DEVELOPMENT SECTION.

1. Wood's challenge to steel and concrete.
2. Relative economy of wood, steel and concrete structures.
3. Manufacture of small dimension stock as a rural industry.
4. The truth about fire hazard in timber structures.
5. Cheaper and better gable roofing with wood shingle.
6. Treated wood for earthquake resistant structures.
7. Treated wood poles for electric distribution and service.
8. Preservation of Indian woods with Ascu wood preservative.
9. Special factors affecting timber design.
10. Better and cheaper fencing.
11. How to build wooden earthquake and storm proof houses
12. Superiority of treated wood as modern structural material.
13. Relative cost of treated electric poles and overhead construction in India and abroad.
14. Specifications for treated wood poles for overhead electrical construction.
15. Treated timber bridges for Indian highways and railways.
16. The role of timber in hanger and aerodrome structures.
17. Comparison of cost of treating Railway sleepers with Ascu and creosote.
18. Wood *versus* steel for framed buildings.
19. How to build fire-resistant timber structures.
20. Fire-proofing of wood.
21. Treated wood for roof trusses.
22. Treated wood for floors.
23. Treated wood for walls and ceilings.
24. Treated wood for file foundations.
25. Treated wood for marine construction.
26. Wood *versus* steel for doors and windows.
27. Treated wood for tanks.
28. Cheap telephone construction.
29. Uses of forest thinnings.
30. Treated wood for agricultural construction.
31. Treated wood for mining construction.
32. Treated wood for irrigation and hydro-electric development.
33. Treated wood for ships and barges.
34. How to put up an inexpensive fire-place in a wooden house.

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